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WORLDWIDE OMEGA AND VERY LOW FREQUENCY (VLF) TRANSMITTER OUTAGE--ETC(U)
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# WORLDWIDE OMEGA AND VERY LOW FREQUENCY (VLF) TRANSMITTER OUTAGES JANUARY TO DECEMBER 1980


Lorraine Rzonca

FEDERAL AVIATION ADMINISTRATION TECHNICAL CENTER
Atlantic City Airport, New Jersey 08405




DATA REPORT

MAY 1981





Prepared for

U. S. DEPARTMENT OF TRANSPORTATION
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15. Supplementary Notes

16. Abstract

An investigation of worldwide OMEGA and very low frequency (VLF) transmitter outages during 1980 was conducted with emphasis on simultaneous outages. Data includes frequency and duration of simultaneous outages and total yearly percentage shutdown for each transmitter. Scheduled outages are specifically noted. The most significant dual OMEGA outage lasted 4.9 hours when the Argentina transmitter was shut-down to correct tower structural problems while La Reunion was down for annual maintenance.

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# PREFACE

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## INTRODUCTION

### PURPOSE.

The purpose of this continuing investigation is to note the frequency of occurrence and the duration of simultaneous outages at two or more OMEGA transmitters, and to examine the possible impact of these outages upon OMEGA coverage. This study also examines the outages at very low frequency (VLF) stations since the current generation of airborne OMEGA receivers often includes a "VLF option," whereby VLF signals serve as a backup when OMEGA signals are insufficient. Results reported on a yearly basis will serve as a comprehensive history of OMEGA transmitter and VLF transmitter outages.

### BACKGROUND.

The Federal Aviation Administration (FAA) is currently investigating radio navigation systems to determine the system or system mix needed to safely and efficiently meet civil aviation requirements for the post 1995 time period. One system under study is OMEGA, a VLF hyperbolic radio navigation system consisting of eight transmitters positioned around the globe to provide worldwide navigation with a predicted accuracy of 2 to 4 nautical miles (95-percent confidence). OMEGA is well suited for oceanic flights and for some domestic area navigation (RNAV) as a supplement to very high frequency omnidirectional radio range (VOR) and distance measuring equipment (DME). The FAA is currently examining several major criteria for radio navigation systems. One major criterion is signal coverage sufficient to support civil aviation operations for established air routes.

Another criterion is reliability. Signals must be available and continuous when needed for safe operation of civil aircraft. With a system like OMEGA, for which only eight transmitters provide global coverage, simultaneous outages could leave large geographic areas without adequate radio navigation coverage. The expected frequency and duration of such outages is an important factor in determining the overall OMEGA system performance. For this reason, an investigation was initiated in 1978 to document OMEGA transmitter outages. Results have been reported in the FAA Technical Center letter reports Nos. NA-78-61-LR, "OMEGA Transmitter Outages, January 1976 to June 1978;" NA-79-26-LR, "OMEGA Transmitter Outages, January to December 1978;" and technical report No. FAA-CT-80-196, "OMEGA Transmitter Outages, January to December 1979." Since the OMEGA system has not yet reached its ultimate level of operation (temporary station Trinidad discontinued transmission on December 31, 1980; station Australia may become operational in 1981), transmitters are shutdown occasionally for various modifications and adjustments. Routine annual maintenance is also required for each transmitter. Prior notification of the scheduled shutdowns is available from the United States (U.S.) Coast Guard OMEGA Navigation System Operations Detail (ONSOD) either by teletype or recorded telephone message. In addition to scheduled outages, occasional unexpected problems may necessitate shutdown of the transmitter equipment. OMEGA transmitter outages during each week are listed in ONSOD teletypes and are also published in "Daily Phase Values and Time Differences, Series 4," of the U.S. Naval Observatory.

Because many manufacturers recognize that OMEGA coverage "holes" can be eliminated or reduced by using VLF signals to supplement insufficient OMEGA signals, the investigation reported here has been extended to include VLF station outages. The VLF stations, operated by the U.S. Navy, are not commissioned to provide signals for navigation. These stations may be shutdown without prior notification to civilian users at the

discretion of the U.S. Navy. Those VLF outages which have occurred during the past week are published in "Daily Phase Values and Time Differences, Series 4," of the U.S. Naval Observatory.

PROCEDURES.

Published values of OMEGA transmitter downtimes of duration greater than 2 minutes have been entered on disk file for the FAA Technical Center Honeywell 66/60 computer for the time period January to December 1980. (For the purposes of this report, any downtime extending into the following day is counted as a separate occurrence; therefore, the maximum duration possible is 1,440 minutes.) The processed data has been examined with respect to the frequency and duration of downtimes, occurrence of simultaneous outages, and total yearly shutdown for each transmitter (with scheduled downtime specifically noted).

Identification of each OMEGA transmitter is made according to the following codes:

1 = Norway = A
2 = Liberia = B
3 = Hawaii = C
4 = North Dakota = D
5 = La Reunion = E
6 = Argentina = F
7 = Trinidad = G
8 = Japan = H

The number code is used throughout this report; the letter code is that used in ONSOD teletype messages and signal coverage diagrams.

Published values of VLF transmitter outages and instances of unstable signals (durations greater than 2 minutes) have been compiled for the period January to December 1980. These data have been analyzed with respect to frequency and duration of outages (or unstable signal), outages coincident with dual OMEGA outages, and total yearly shutdown for each VLF transmitter.

Identification of each VLF transmitter is made according to the following code:

NWC = Northwest Cape, Australia (22.35 kilohertz (kHz))

NDT = Yosami, Japan (17.45 kHz)

GBR = Rugby, England (16.00 kHz)

NAA = Cutler, Maine, U.S.A. (17.85 kHz)

NPM = Lualualei, Hawaii, U.S.A. (23.45 kHz)

NSS = Annapolis, Maryland, U.S.A. (21.45 kHz)

NLK = Jim Creek, Washington, U.S.A. (18.625 kHz)

DISCUSSION

Table 1 identifies OMEGA stations which were simultaneously off the air for 3 minutes or longer and lists the date, start time, and duration of each simultaneous outage. Transmitters scheduled to be down during the indicated time period are denoted by asterisks. (Scheduled downtime is defined as the actual outage which occurred within the approximate time frame previously published for the anticipated shutdown.) Almost all of the dual outages occurred when one of the stations was down for annual maintenance. The exceptions were Liberia - La Reunion on January 27 (three dual outages of duration of 10 minutes or less), and Liberia - Argentina on December 4 (6 minutes). The longest dual outage (4.9 hours) occurred on July 13, 1980 when Argentina experienced tower structural problems while La Reunion was down for annual maintenance. This was the only dual

outage of duration greater than 2 hours. (In 1979 there were seven such outages.) All simultaneous outages of duration greater than 1 hour occurred in July. For 1980, durations of simultaneous outages ranged from 3 to 291 minutes with a median of 6 minutes (in 1979 the median was 28 minutes).

Table 2 sums the durations of simultaneous outages for each OMEGA station pair for 1980. The yearly total for each pair is listed together with subtotals for cases where only one of the two stations, or both stations, or neither station was scheduled down. La Reunion - Argentina was the major contributor. The next largest contributor was Hawaii - Trinidad, when Trinidad had equipment problems during Hawaii's annual maintenance period.

Table 3 shows the monthly and yearly average percentage of total and scheduled downtime for each OMEGA transmitter. La Reunion leads in yearly downtime (6.4 percent) caused by lengthy annual maintenance time in July and loss of synchronization in November. Next is Japan (4.6 percent) due to annual maintenance downtime. Stations which experienced no unexpected problems (effectively, all downtime was scheduled in advance) include Norway, Hawaii, North Dakota, Trinidad, and Japan. La Reunion shows the largest discrepancy between scheduled and total downtime (0.7 percent for the year) because of the loss of synchronization in November; the other stations show 0.3 percent or less for unscheduled downtime.

Table 4 lists the annual maintenance period for each OMEGA transmitter, the total hours scheduled downtime during this period, the hours that the transmitter was actually down, and the percentage of the scheduled downtime during which another transmitter was down simultaneously. The scheduled maintenance periods vary in length, depending upon anticipated maintenance requirements. Periods varied from 2.7 days (North Dakota) to 27.5 days (La Reunion), while the actual downtime ranged from 1.7 days (North Dakota) to 20.8 days (La Reunion) with a median of 9.5 days and an average of 9.7 days. This average value is approximately 3 days longer than that for the previous 2 years. Simultaneous outages during the maintenance time for any given station comprised one percent or less of the station scheduled downtime. The sum total of all the simultaneous outages during maintenance times represents 0.6 percent of the total maintenance time (seven stations) and represents 0.1 percent of the entire year.

Simultaneous outages, especially those of long duration, may critically affect signal coverage in those geographic locations which receive fewer than five acceptable signals (adequate signal-to-noise ratio, good geometry, or no modal interference). A first approximation in determining these geographic locations may be obtained from a composite OMEGA coverage diagram distributed by ONSOD. Such diagrams indicate regions in which predicted signal-to-noise ratio for 10.2 kHz is greater than -20 decibels (dB) and in which modal interference is expected to be insignificant. (Diagrams are also available for receiver sensitivity of -30 dB.)

The signal-to-noise ratios are computed for OMEGA propagation conditions applicable at either 0600 or 1800 Greenwich Mean Time (GMT), and applicable to the months of February, May, August, and November; conditions for other months/times would have to be approximated. By examining the diagram for those regions which would be left with only one or two OMEGA stations if a particular dual outage occurred, a contour map may be drawn to highlight those regions with inadequate signal coverage for the duration of the dual outage. For the La Reunion - Argentina outage of 291 minutes on July 13, 1980 (starting at 1909 GMT), figure 1 depicts those areas which were left with only one or

two OMEGA signals when La Reunion and Argentina went off the air. This diagram applies to OMEGA receivers with signal sensitivity of -20 dB. The available stations (identified by number codes 1 through 8) are listed, with La Reunion and Argentina omitted. Based on this coverage diagram, navigation in the Indian Ocean, the areas near Australia, Central and South Africa, and a large portion of the South Atlantic Ocean could have been adversely affected for the 4.8-hour period.

An OMEGA receiver with increased signal sensitivity (-30 dB) would not have been affected in the South Atlantic area, as shown in figure 2; however, signal coverage in Africa, the Indian Ocean, and the Australia area would still have been inadequate.

OMEGA receivers equipped with VLF option would have fared better in the Indonesia and Australia vicinity if they were able to use the Japan (NDT), Hawaii (NPM), and Australia (NWC) VLF stations to supplement the remaining OMEGA signals.

Regions expected to be affected by the dual outage involving Hawaii and Trinidad on June 4, 1980 (57 minutes starting 0105 GMT) are highlighted in figure 3 for a -20 dB receiver. Northern Canada, the bulk of the United States, the Pacific Ocean bordering the U.S. and Mexico, the Pacific Ocean south of the U.S. and including the Polynesian area, and a region extending from Brazil to the West Coast of Africa would have lacked adequate OMEGA signal coverage for receivers with signal thresholds of -20 dB. Available signals during the Hawaii - Trinidad outage are identified by the station number codes (1 through 8). For a -30 dB receiver, figure 4 shows that the Brazil to Africa area would have remained navigable and northern Canada would have had adequate coverage; however, the Continental U.S. and Pacific Ocean areas would still have lacked sufficient OMEGA signals. OMEGA sets equipped with VLF option could have used the VLF stations to supplement the remaining OMEGA signals for the duration of the dual OMEGA outage. (Coverage diagrams for VLF communication signals were not available.)

Because of the increasing use of VLF signals to supplement OMEGA signals in OMEGA/VLF navigation systems, the VLF outages which occurred during 1980 were examined. Special attention was given to the VLF outages which were concurrent with dual OMEGA outages. Table 5 lists the start time and duration of VLF outages during dual OMEGA outages. All such cases lasted no longer than 10 minutes, with a median of 4 minutes and average of 5 minutes. This type of situation should not have had any serious impact on OMEGA/VLF navigation systems. Table 6 lists the monthly and yearly percentages of downtime, or unstable signal, for each VLF station. The longest downtime was 2-1/2 months (January, February, March) for the Hawaii station (NPM). Next was the Jim Creek, Washington, station (NLK) with a cumulative total of 1 week in July, followed by Annapolis, Maryland, (NSS) with 2 days in January.

## SUMMARY

1. During 1980 there were no triple OMEGA outages (four occurred in 1979) and only one dual OMEGA outage lasted more than 2 hours (seven occurred in 1979).

2. Almost all dual OMEGA outages occurred when one of the stations was down for annual maintenance. Four exceptions were of short duration (10 minutes or less).

3. The longest dual OMEGA outage was 4.9 hours in July when Argentina tower structural problems coincided with La Reunion annual maintenance time. This situation reduced theoretical OMEGA signal coverage to only one or two OMEGA

signals (inadequate for navigation) in Africa, the Indian Ocean, areas near Australia, and possibly areas in the South Atlantic (depending upon OMEGA receiver sensitivity).

4. A 57-minute dual OMEGA outage involving Hawaii and Trinidad reduced theoretical OMEGA signal coverage in the bulk of the U.S., the Pacific Ocean west and south of the United States, the Polynesian area, and possibly northern Canada and the area from Brazil to Africa (depending upon OMEGA receiver sensitivity).

5. OMEGA navigation systems equipped with VLF option would have supplemented the one or two remaining OMEGA signals with several Navy VLF signals and effectively filled in the OMEGA coverage holes which resulted during dual OMEGA outages.

6. A measure of OMEGA and VLF signal reliability was obtained by calculating yearly percentage of transmitter downtime. Normal operation for the OMEGA stations ranged from 93.6 percent (La Reunion) to 99.8 percent (Trinidad); the average was 97.5 percent. Normal operation for the Navy VLF stations ranged from 78.5 percent (NPM Hawaii) to 99.9 percent (NDT Japan, NAA Cutler, Maine); the average was 96.5 percent. Prior notification of transmitter downtime was excellent for the Norway, Hawaii, North Dakota, Trinidad, and Japan OMEGA stations; less than 0.2 percent downtime was unscheduled.

7. Actual cumulative downtime during 1980 annual maintenance ranged from 1.7 days (North Dakota) to 20.8 days (La Reunion), with an average of 9.7 days. This average was approximately 3 days longer than that for the previous 2 years.

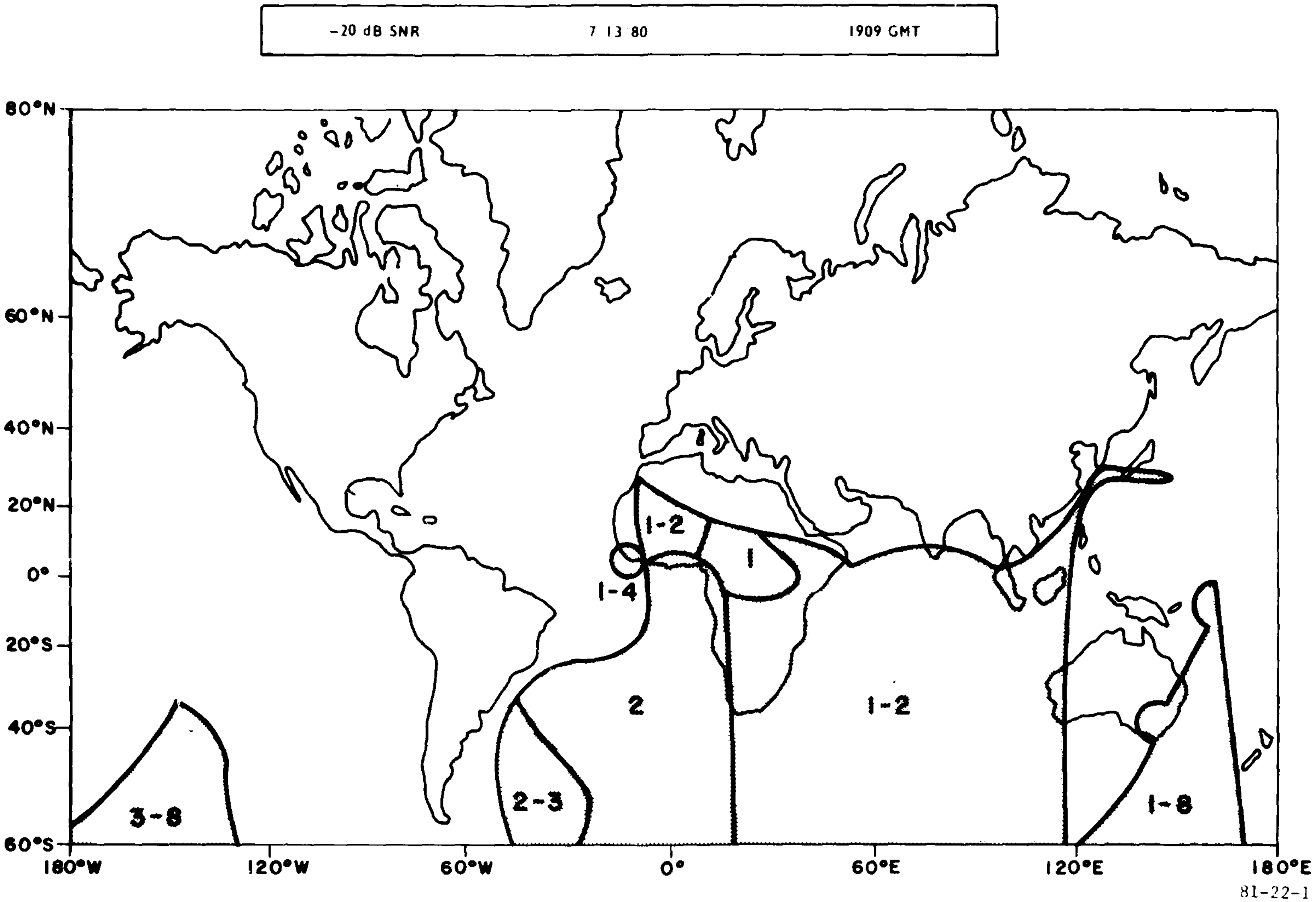


FIGURE 1. INADEQUATE SIGNAL COVERAGE DURING LA REUNION - ARGENTINA OUTAGE (-20 dB RECEIVER)

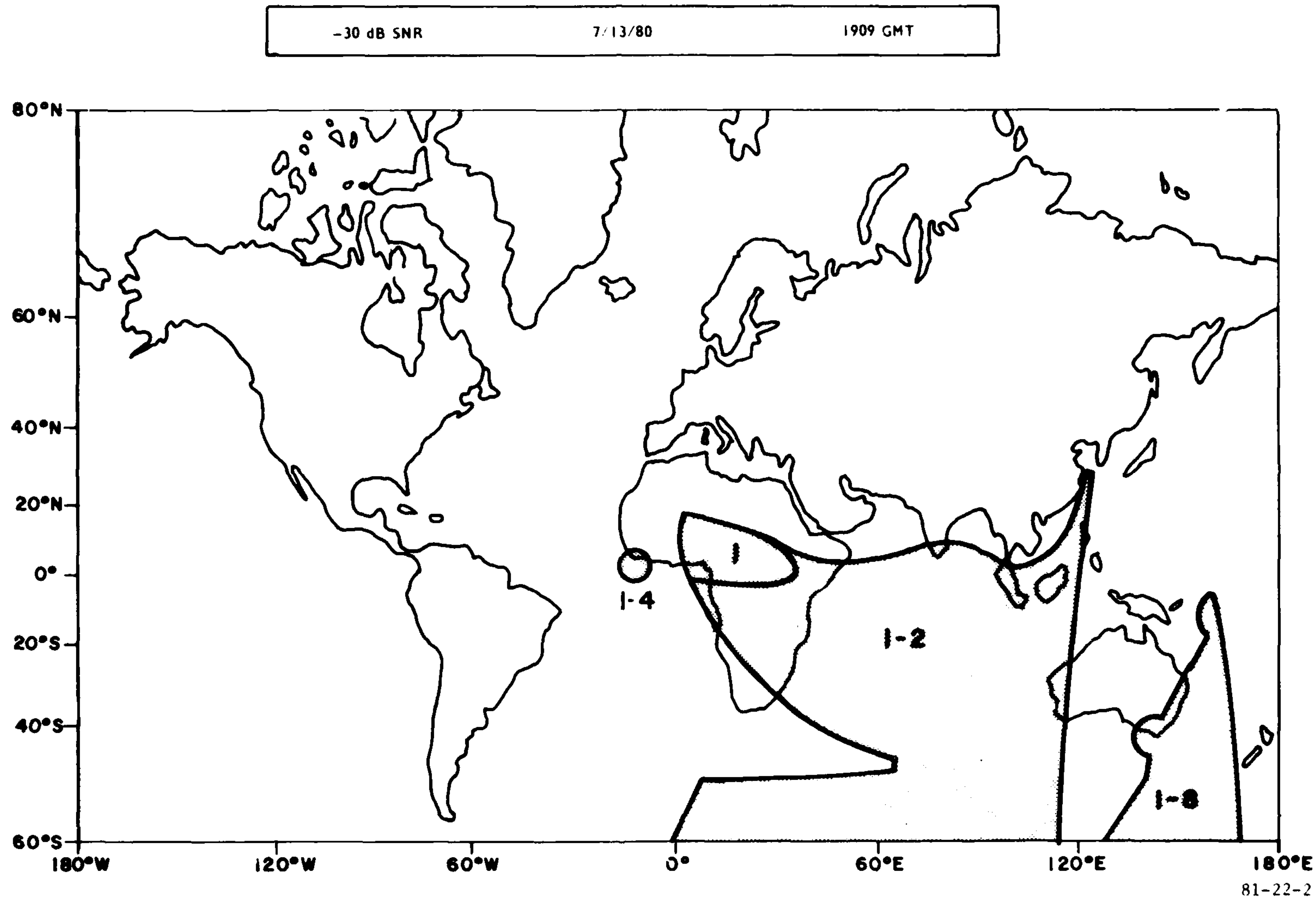


FIGURE 2. INADEQUATE SIGNAL COVERAGE DURING LA REUNION - ARGENTINA OUTAGE (-30 dB RECEIVER)

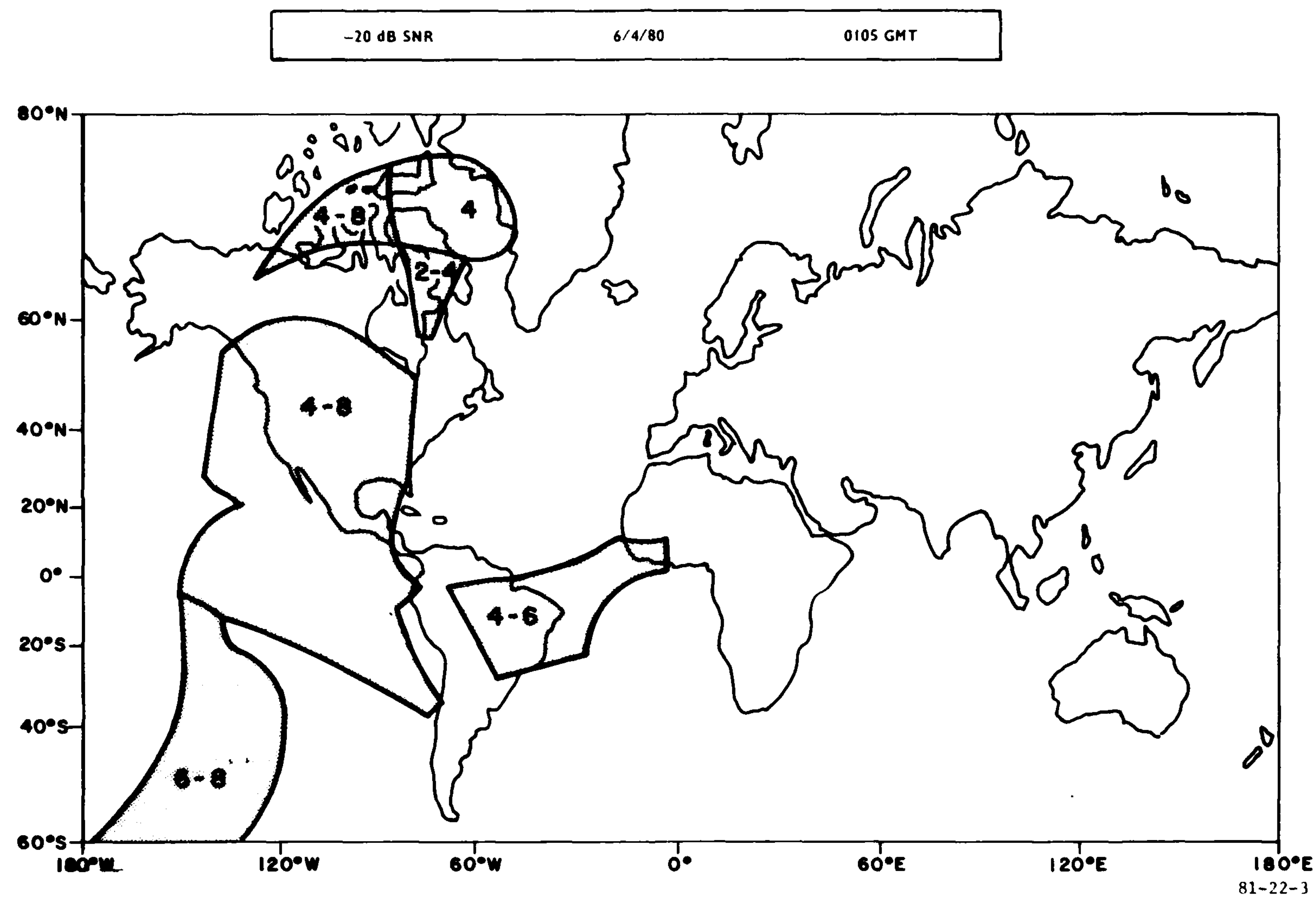


FIGURE 3. INADEQUATE SIGNAL COVERAGE DURING HAWAII - TRINIDAD OUTAGE (-20 dB RECEIVER)

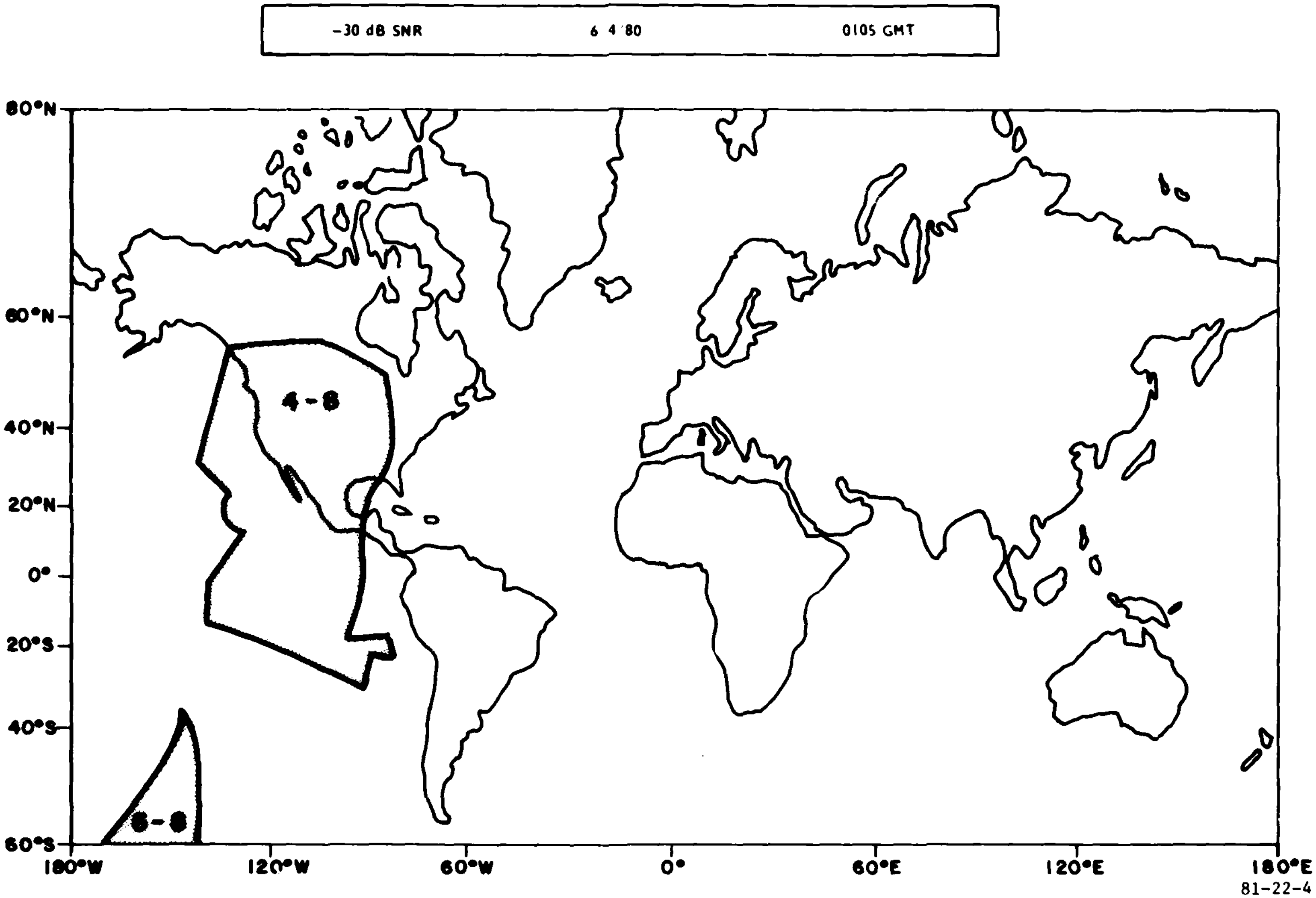


FIGURE 4. INADEQUATE SIGNAL COVERAGE DURING HAWAII - TRINIDAD OUTAGE (-30 dB RECEIVER)

TABLE 1. OMEGA TRANSMITTER DUAL OUTAGES $\geq$ 3 MINUTES

| Date (1980) | Transmitters | Duration (min) | Start Time (GMT) |
|---|---|---|---|
| 1/27 | 2 - 5 | 10 | 0725 |
| 1/27 | 2 - 5 | 9 | 0826 |
| 1/27 | 2 - 5 | 3 | 0937 |
| 2/4 | *2 - 6 | 5 | 1648 |
| 2/15 | *2 - 7 | 4 | 1202 |
| 3/3 | 5 - 6* | 5 | 1202 |
| 3/3 | 5 - 6* | 3 | 1400 |
| 3/6 | *6 - 7 | 3 | 1630 |
| 6/3 | 1 - 3* | 5 | 1201 |
| 6/4 | *3 - 7 | 57 | 0105 |
| 6/6 | *3 - 8 | 3 | 0613 |
| 6/15 | *3 - 8 | 20 | 0606 |
| 7/2 | 2 - 5* | 10 | 2005 |
| 7/3 | *5 - 8 | 3 | 0813 |
| 7/8 | *5 - 7 | 7 | 1410 |
| 7/13 | *5 - 6 | 105 | 1407 |
| 7/13 | *5 - 6 | 291 | 1909 |
| 7/15 | 3 - 5* | 9 | 1845 |
| 7/16 | 2 - 5* | 6 | 0426 |
| 7/19 | *5 - 6 | 5 | 2019 |
| 7/19 | *5 - 6 | 64 | 2105 |
| 8/8 | *1 - 5 | 8 | 0422 |
| 8/10 | *1 - 6 | 20 | 2340 |
| 8/11 | *1 - 6 | 7 | 0000 |
| 8/12 | *1 - 4 | 4 | 0120 |
| 8/12 | *1 - 6 | 12 | 1205 |
| 8/15 | *1 - 2 | 6 | 1104 |
| 8/15 | *1 - 3 | 4 | 1351 |
| 8/15 | *1 - 5 | 13 | 2147 |
| 9/9 | *4 - 5 | 6 | 0358 |
| 9/9 | *4 - 5 | 4 | 0406 |
| 9/10 | *4 - 8 | 3 | 1522 |
| 10/15 | 7 - 8* | 5 | 1120 |
| 10/15 | 6 - 8* | 6 | 1242 |
| 10/18 | 7 - 8* | 4 | 0106 |
| 10/21 | 2 - 8* | 4 | 1046 |
| 10/21 | 6 - 8* | 14 | 1254 |
| 10/24 | 7 - 8* | 3 | 2052 |
| 10/26 | 7 - 8* | 20 | 1806 |
| 10/28 | 7 - 8* | 4 | 1737 |
| 12/04 | 2 - 6 | 6 | 0409 |

*Scheduled outage

NOTE: There were no simultaneous outages during the months of April, May, and November.

TABLE 2. YEARLY TOTAL OF OMEGA SIMULTANEOUS OFF-AIR TIMES

| | Duration Off-Air (Minutes) | | | |
|---|---|---|---|---|
| Transmitters | Total | One Scheduled | Both Scheduled | Neither Scheduled |
| 5 - 6 | 473 | 473 | 0 | 0 |
| 3 - 7 | 57 | 57 | 0 | 0 |
| 1 - 6 | 39 | 39 | 0 | 0 |
| 2 - 5 | 38 | 16 | 0 | 22 |
| 7 - 8 | 36 | 36 | 0 | 0 |
| 3 - 8 | 23 | 23 | 0 | 0 |
| 1 - 5 | 21 | 21 | 0 | 0 |
| 6 - 8 | 20 | 20 | 0 | 0 |
| 2 - 6 | 11 | 5 | 0 | 6 |
| 4 - 5 | 10 | 10 | 0 | 0 |
| 3 - 5 | 9 | 9 | 0 | 0 |
| 1 - 3 | 9 | 9 | 0 | 0 |
| 5 - 7 | 7 | 7 | 0 | 0 |
| 1 - 2 | 6 | 6 | 0 | 0 |
| 2 - 7 | 4 | 4 | 0 | 0 |
| 1 - 4 | 4 | 4 | 0 | 0 |
| 2 - 8 | 4 | 4 | 0 | 0 |
| 6 - 7 | 3 | 3 | 0 | 0 |
| 5 - 8 | 3 | 3 | 0 | 0 |
| 4 - 8 | 3 | 3 | 0 | 0 |

TABLE 3. PERCENTAGE TIME OMEGA TRANSMITTERS OFF-AIR

| Transmitter | Month | Percentage Time Off-Air: Total | Percentage Time Off-Air: Scheduled |
|---|---|---|---|
| NORWAY | JAN | 0+ | 0.0 |
| | FEB | 0.3 | 0.0 |
| | MAR | 0.0 | 0.0 |
| | APR | 0.0 | 0.0 |
| | MAY | 0.0 | 0.0 |
| | JUN | 0+ | 0.0 |
| | JUL | 0.0 | 0.0 |
| | AUG | 30.8 | 30.8 |
| | SEP | 0.0 | 0.0 |
| | OCT | 0.0 | 0.0 |
| | NOV | 0.0 | 0.0 |
| | DEC | 0.0 | 0.0 |
| | | Year average 2.6 | Year average 2.6 |
| LIBERIA | JAN | 0.6 | 0.0 |
| | FEB | 35.3 | 35.0 |
| | MAR | 0.2 | 0.0 |
| | APR | 0.2 | 0.0 |
| | MAY | 0+ | 0.0 |
| | JUN | 0.1 | 0.0 |
| | JUL | 0+ | 0.0 |
| | AUG | 0.1 | 0.0 |
| | SEP | 0.8 | 0.0 |
| | OCT | 0.2 | 0.0 |
| | NOV | 0+ | 0.0 |
| | DEC | 1.0 | 0.3 |
| | | Year average 3.2 | Year average 2.9 |
| HAWAII | JAN | 0.1 | 0.0 |
| | FEB | 0+ | 0.0 |
| | MAR | 0+ | 0.0 |
| | APR | 0+ | 0.0 |
| | MAY | 0.0 | 0.0 |
| | JUN | 16.1 | 16.1 |
| | JUL | 0.1 | 0.0 |
| | AUG | 0+ | 0.0 |
| | SEP | 0.2 | 0.0 |
| | OCT | 0.0 | 0.0 |
| | NOV | 0.2 | 0.2 |
| | DEC | 0+ | 0.0 |
| | | Year average 1.4 | Year average 1.4 |

TABLE 3. PERCENTAGE TIME OMEGA TRANSMITTERS OFF-AIR (CONTINUED)

| Transmitter | Month | Percentage Time Off-Air Total | Percentage Time Off-Air Scheduled |
|---|---|---|---|
| NORTH DAKOTA | JAN | 0.2 | 0.0 |
| | FEB | 0+ | 0.0 |
| | MAR | 0.0 | 0.0 |
| | APR | 0+ | 0.0 |
| | MAY | 0+ | 0.0 |
| | JUN | 0+ | 0.0 |
| | JUL | 0+ | 0.0 |
| | AUG | 0.1 | 0+ |
| | SEP | 5.8 | 5.8 |
| | OCT | 0.1 | 0.1 |
| | NOV | 0+ | 0.0 |
| | DEC | 0.3 | 0.0 |
| | | Year average 0.5 | Year average 0.5 |
| LA REUNION | JAN | 1.7 | 0.6 |
| | FEB | 0.1 | 0.0 |
| | MAR | 0.1 | 0.0 |
| | APR | 0+ | 0.0 |
| | MAY | 0+ | 0.0 |
| | JUN | 0.0 | 0.0 |
| | JUL | 67.8 | 67.7 |
| | AUG | 0.1 | 0.0 |
| | SEP | 0.2 | 0.0 |
| | OCT | 0.1 | 0.1 |
| | NOV | 6.4 | 0.0 |
| | DEC | 0+ | 0.0 |
| | | Year average 6.4 | Year average 5.7 |
| ARGENTINA | JAN | 0+ | 0.0 |
| | FEB | 0+ | 0.0 |
| | MAR | 14.2 | 14.1 |
| | APR | 0.1 | 0.0 |
| | MAY | 0.0 | 0.0 |
| | JUN | 0.1 | 0.0 |
| | JUL | 1.1 | 0.0 |
| | AUG | 0.3 | 0.0 |
| | SEP | 0.0 | 0.0 |
| | OCT | 0.1 | 0.0 |
| | NOV | 0.1 | 0.0 |
| | DEC | 0.9 | 0.0 |
| | | Year average 1.4 | Year average 1.2 |

TABLE 3. PERCENTAGE TIME OMEGA TRANSMITTERS OFF-AIR (CONTINUED)

| Transmitter | Month | Percentage Time Off-Air: Total | Percentage Time Off-Air: Scheduled |
|---|---|---|---|
| TRINIDAD | JAN | 0.0 | 0.0 |
| | FEB | 0.1 | 0.0 |
| | MAR | 0.1 | 0.0 |
| | APR | 0.1 | 0.0 |
| | MAY | 0.1 | 0.0 |
| | JUN | 0.3 | 0.0 |
| | JUL | 0+ | 0.0 |
| | AUG | 0.1 | 0.0 |
| | SEP | 0.9 | 0.7 |
| | OCT | 0.1 | 0.0 |
| | NOV | 0.0 | 0.0 |
| | DEC | 0.1 | 0.0 |
| | | Year average 0.2 | Year average 0.1 |
| JAPAN | JAN | 0+ | 0.0 |
| | FEB | 0+ | 0.0 |
| | MAR | 0+ | 0.0 |
| | APR | 1.3 | 1.3 |
| | MAY | 0.0 | 0.0 |
| | JUN | 0.1 | 0.0 |
| | JUL | 0+ | 0.0 |
| | AUG | 0.0 | 0.0 |
| | SEP | 0+ | 0.0 |
| | OCT | 53.0 | 53.0 |
| | NOV | 0.6 | 0.6 |
| | DEC | 0+ | 0.0 |
| | | Year average 4.6 | Year average 4.6 |

NOTE: 0+ = value < 0.05 but nonzero

TABLE 4. SIMULTANEOUS OMEGA OUTAGES DURING ANNUAL MAINTENANCE (1980)

| Transmitter | Maintenance Dates | Total Hours Scheduled | Hours Off Actual | % Time Sim. Outages |
|---|---|---|---|---|
| LIBERIA | FEB 1 TO 15 | 360 | 244 | 0.04 |
| ARGENTINA | MAR 3 TO 7<br>MAR 10 TO 14 | 208 | 105 | 0.09 |
| HAWAII | JUN 2 TO 16 | 336 | 116 | 0.42 |
| LA REUNION | JUL 1 TO 28 | 659 | 499 | 1.26 |
| NORWAY | AUG 7 TO 16 | 233 | 229 | 0.53 |
| NORTH DAKOTA | SEP 8 TO 12 | 64 | 42 | 0.34 |
| JAPAN | OCT 13 TO 30 | 416 | 394 | 0.24 |

NOTE: Trinidad transmitter omitted since it was a temporary station (permanently shut down at 2400 UT on December 31, 1980).

Actual maintenance time ranged from 1.7 to 20.8 days, with an average of 9.7 days.

TABLE 5. VLF OUTAGES DURING SIMULTANEOUS OMEGA OUTAGES

| Date (1980) | Transmitters OMEGA | VLF | Duration (minutes) | Start (GMT) |
|---|---|---|---|---|
| 1/27 | 2 - 5 | NPM | 10 | 0725 |
| 1/27 | 2 - 5 | NPM | 9 | 0826 |
| 1/27 | 2 - 5 | NPM | 3 | 0937 |
| 2/4 | *2 - 6 | NPM | 5 | 1648 |
| 2/15 | *2 - 7 | NPM | 4 | 1202 |
| 3/3 | 5 - 6* | NPM | 5 | 1202 |
| 3/3 | 5 - 6* | NPM | 3 | 1400 |
| 3/6 | *6 - 7 | NPM | 3 | 1630 |
| 7/2 | 2 - 5* | NLK | 10 | 2005 |
| 7/3 | *5 - 8 | NLK | 3 | 0813 |

*Scheduled outage

TABLE 6. PERCENTAGE TIME VLF OFF-AIR/UNSTABLE (1980)

| | | Percentage Time | |
|---|---|---|---|
| Transmitter | Month | Off-Air | Unstable |
| NWC | JAN | 0.+ | 0.0 |
| | FEB | 0.0 | 0.0 |
| | MAR | 0.1 | 0.0 |
| | APR | 0.1 | 0.0 |
| | MAY | 0.1 | 0.0 |
| | JUN | 0.3 | 0.0 |
| | JUL | 0.3 | 0.0 |
| | AUG | 0.1 | 0.0 |
| | SEP | 0.3 | 0.0 |
| | OCT | 0.5 | 0.0 |
| | NOV | 0.1 | 0.0 |
| | DEC | 0.0 | 0.0 |
| | | Year average 0.2 | Year average 0.0 |
| NDT | JAN | 0.0 | 0.0 |
| | FEB | 0.0 | 0.0 |
| | MAR | 0.1 | 0.0 |
| | APR | 0+ | 0.0 |
| | MAY | 0+ | 0.0 |
| | JUN | 0.0 | 0.0 |
| | JUL | 0.4 | 0.0 |
| | AUG | 0+ | 0.0 |
| | SEP | 0.0 | 0.0 |
| | OCT | 0.2 | 0.0 |
| | NOV | 0.1 | 0.0 |
| | DEC | 0.0 | 0.0 |
| | | Year average 0.1 | Year average 0.0 |
| GBR | JAN | 0.0 | 0.0 |
| | FEB | 0.0 | 0.0 |
| | MAR | 0.0 | 0.1 |
| | APR | 0.0 | 0.1 |
| | MAY | 0.0 | 0.6 |
| | JUN | 0.0 | 0+ |
| | JUL | 0.0 | 0.1 |
| | AUG | 0.0 | 0.1 |
| | SEP | 0.0 | 0.4 |
| | OCT | 0.0 | 0.0 |
| | NOV | 0.6 | 0.3 |
| | DEC | 0.2 | 0.2 |
| | | Year average 0.1 | Year average 0.2 |

TABLE 6. PERCENTAGE TIME VLF OFF-AIR/UNSTABLE (1980) (CONTINUED)

| Transmitter | Month | Percentage Time Off-Air | | Percentage Time Unstable |
|---|---|---|---|---|
| NAA | JAN | 0.0 | | 0.0 |
| | FEB | 0+ | | 0.0 |
| | MAR | 0+ | | 0.0 |
| | APR | 0+ | | 0.0 |
| | MAY | 0+ | | 0.0 |
| | JUN | 0.6 | | 0.0 |
| | JUL | 0+ | | 0.0 |
| | AUG | 0.1 | | 0.0 |
| | SEP | 0.2 | | 0.0 |
| | OCT | 0+ | | 0.0 |
| | NOV | 0.0 | | 0.0 |
| | DEC | 0.0 | | 0.0 |
| | Year average | 0.1 | Year average | 0.0 |
| NPM | JAN | 100.0 | | 0.0 |
| | FEB | 100.0 | | 0.0 |
| | MAR | 49.2 | | 0.0 |
| | APR | 0.3 | | 0.0 |
| | MAY | 1.3 | | 0.0 |
| | JUN | 0.1 | | 0.0 |
| | JUL | 3.0 | | 0.0 |
| | AUG | 1.3 | | 0.0 |
| | SEP | 0.1 | | 0.0 |
| | OCT | 0+ | | 0.0 |
| | NOV | 2.2 | | 0.0 |
| | DEC | 0.1 | | 0.0 |
| | Year average | 21.5 | Year average | 0.0 |
| NSS | JAN | 6.5 | | 0.0 |
| | FEB | 0+ | | 0.0 |
| | MAR | 0.1 | | 0.0 |
| | APR | 0.0 | | 0.0 |
| | MAY | 0+ | | 0.0 |
| | JUN | 0+ | | 0.0 |
| | JUL | 0.0 | | 0.0 |
| | AUG | 0.1 | | 0.0 |
| | SEP | 0+ | | 0.0 |
| | OCT | 0+ | | 0.0 |
| | NOV | 0+ | | 0.0 |
| | DEC | 0.0 | | 0.0 |
| | Year average | 0.6 | Year average | 0.0 |

TABLE 6. PERCENTAGE TIME VLF OFF-AIR/UNSTABLE (1980) (CONTINUED)

| | | Percentage Time | |
|---|---|---|---|
| Transmitter | Month | Off-Air | Unstable |
| NLK | JAN | 0.2 | 0.0 |
| | FEB | 0.0 | 0.0 |
| | MAR | 0.4 | 0.0 |
| | APR | 0+ | 0.0 |
| | MAY | 0.1 | 0.0 |
| | JUN | 1.5 | 0.0 |
| | JUL | 20.5 | 0.2 |
| | AUG | 0+ | 0.0 |
| | SEP | 0.0 | 0.0 |
| | OCT | 0.1 | 0.0 |
| | NOV | 0.0 | 0.0 |
| | DEC | 0+ | 0.0 |
| | | Year average 1.9 | Year average 0+ |

NOTE: 0+ = value < 0.05 but nonzero

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